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(54) MOTOR FOR SUBMERGED PUMP

(57) An electric motor of a submersible pump includes a body (1) with a core (2) of a stator arranged therein, in slots (9) of a tooth zone (8) of which multiturn sections of a two-layer winding are disposed with face parts, and a rotor (5). The core (2) of the stator comprises two parts (6, 7), an inner part with slots (9) open to the side of the periphery of the part (6), and an outer part (7) that is an annular yoke. Each section of the stator winding has a substantially square cross section and is formed by turns (12) of wire of substantially rectangular cross section, the turns lying adjacent each other along their large surfaces, wherein a first and a second side of each section are positioned in different layers (13, 14) of the two-layer winding so that in each slot (9) the large surfaces of the turns (12) in the layers (13, 14) of the winding are oriented mutually perpendicular, and the height of the face parts does not exceed the height of the slot (9).

The electric motor serves mainly for use in submersed pump units for submersed wells.

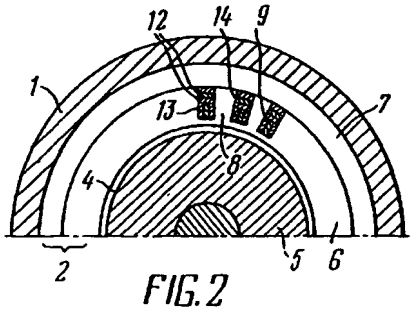

FIG. 2

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Description

FIELD OF THE INVENTION

[0001] The invention relates to the field of elettrica engineering, and more exactly, to electric motors of a submersible pump with a large length-to-diameter ratio.

BACKGROUND OF THE INVENTION

[0002] During the development of wells, in particular oil wells, submersible pump units are used which are equipped with a drive, the dimensions of which should not exceed the diameter of the well. The electric motors usually used as power drives of submerged units, taking this requirement into account, have a large length-to-diameter ratio.

[0003] An electric motor is known which comprises a body, with a laminated stator core arranged therein, in the slots of the tooth zone of which multiturn sections of a two-layer winding are disposed with face parts and a rotor spaced from the stator. In that construction the sections of the two-layer winding are disposed in slots open from the side of the face, wherein the sections may be formed by turns of wire that has a round or rectangular cross secticin depending on the power of the machine (V.V. Dombrovsky, G.M. Khutoretsky, "Basics of Designing Alternating Current Motors," Leningrad, Energiya, 1974, p. 349, Fig. 8-29).

[0004] However, when there is a large ratio of the length of the electric motor to the diameter ($L/d \geq 10$), it is impossible in practice to make a winding of sections laid into slots from the side of the gap.

[0005] A submersible electric motor for a pump is also known, which includes a body, with a laminated stator core arranged therein, in the slots of the tooth zone of which multiturn sections of a two-layer winding are disposed with face parts, and a rotor spaced from the stator (prospectus of the "Konnas" firm - Submersible electric motors).

[0006] This motor has a large length-to-diameter ratio, which excludes the arrangement of a two-layer winding with preliminary formed multiturn sections in the slots of the tooth zone of a laminated core. In such a motor the sections of the winding are made of round wire by the method of broaching through slots. However, when wire with a round cross section is used the filling factor of the winding in the slot is small (the ratio of the cross section of copper to the cross section of the slot), which is accompanied by an increase of the weight and size of the motor, a relatively large thickness of the layer of impregnation compound is required, which increases the thermal resistance for losses in the copper and makes the release of heat into the environment more difficult.

[0007] The method of assembling a motor by broaching wire through a slot, including forming sections of the winding directly in the slot, results in the necessity for rewinding in the case of insufficient electrical strength or damage to the insulation, and also makes the step of laying slot insulation more difficult.

SUMMARY OF THE INVENTION

[0008] The object at the base of the invention is to create an electric motor for a submersible pump, the construction of which would make it possible, with a large ratio of the length of the motor to its diameter, to preliminarily form sections of a two-layer winding of the stator and to arrangement it in the slots of the tooth zone of the core as already formed sections, which would make it possible to enhance the filling factor of a slot and, consequently, reduce the size and weight of the electric motor, and also to increase the productivity of submersible pumps with an electric drive in small diameter wells.

[0009] The stated object is achieved in an electric motor of a submersible pump, which includes a body, with a laminated stator core arranged therein, in the slots of the tooth zone of which multiturn sections of a two-layer winding are disposed with face parts, and a rotor spaced from the stator, in that in accordance with the invention, the stator core comprises two parts, an inner part including a tooth zone with slots open to the side of the periphery of that part, and an outer part encompassing the inner and being an annular yoke, each section of the stator winding has a substantially square cross section and is formed by turns of wire of substantially rectangular cross section, the turns lying adjacent each other along their large surfaces, wherein a first and second side of each section are positioned in different layers of the two-layer winding so that in each slot the large surfaces of the turns in the first and second layers of the winding are oriented mutually perpendicular, and the height of the face parts does not exceed the height of the slot.

[0010] The concept "substantially square cross section" within the limits of this invention is considered as a cross section selected taking the following relationship into account:

$$h = (0,9 - 1,1)\, b,$$

wherein h is the height of the cross section of the section,
b is the width of the cross section of the section.

[0011] The concept "substantially rectangular cross section" assumes any cross section, the length of two opposite sides of which exceeds the length of the two other opposite sides of that cross section.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Further the invention will be explained by a description of concrete variants of its fulfillment together with the appended drawings, in which:

- Fig. 1 shows an electric motor of a submersible pump, in accordance with the invention, in a partial longitudinal section;
- Fig. 2 shows a section along line 11-11 in Fig. 1;
- Fig. 3 shows the face part of the section, in an isometric view.

DETAILED DESCRIPTION OF THE INVENTION

[0013] An electric motor of a submersible pump includes a cylindrical body 1 with a laminated core 2 of a stator 3 mounted in the body and a rotor 5 separated from the stator 3 by a gap 4. The core 2 comprises two parts 6 and 7, of which an inner part 6 includes a tooth zone 8 with slots 9 that are open towards the periphery of that part and an outer part 7 is an annular yoke encompassing the inner part 6. Multiturn sections of a two-layer winding 10 with face parts 11 are placed in the slots 9 of the tooth zone 8. Each section of the winding of the stator has a substantially square cross section, which is selected so as to fulfill the relationship $h = (0,9 - 1,1)b$, where h and b are the height and width of the cross section of the section respectively.

[0014] Each section is formed by a plurality of turns 12 of rectangular cross section, the turns being adjacent one another along their large surfaces, wherein one side of each section is positioned in a first layer 13 of the two-layer winding, the opposite side - in a second layer 14. The sections are laid so that the large surfaces of the turns in the first and second layers 13, 14 of the winding 10 in each slot 9 of the tooth zone 8 are oriented mutually perpendicular, as a result of which the height of the face parts 11 does not exceed the height of the slot 9.

[0015] Assembly of the electric motor is carried out in the following manner. The sections of the winding 10 are made separately from turns of wire of rectangular cross section, wherein the dimensions of the cross section of the section are selected, taking into account the relationship $h=(0,9 - 1,1)b$, where h is the height of the cross section of the section, b is the width of the cross section of the section, which makes it possible to ensure a maximum space filling of the slot. The sections are preliminarily formed and laid into the open to the outside, towards the side of the periphery of part 6, slots 9 of the packet of sheets of the tooth zone 8. After that the packet of sheets of the annular yoke - the outer part 7, which is fixed against turning by any known method (for example by an adhesive) is put on from the outside. The prepared stator 3 with the winding 10 is arranged in the body 1. In order to ensure assembly of the inner part 6 of the tooth zone 8 with the winding 10 and the outer part 7 of the annular yoke, it is necessary that the height of the face parts 11 does not exceed the height of the slot 9. This is achieved in that the face parts 11 of the sections in the zone of transition from the layer 13 to the layer 14 are turned along the axis of the multiturn section, so that the turns of one side of each section, which form one of the two layers 13, 14 of the winding 10, are positioned parallel to the longitudinal axis of the slot 9, while the turns of the second side of each section are positioned perpendicular to that same axis. Making the winding 10 of wire having a rectangular cross section makes it possible to substantially enhance the filling factor of the slot.

[0016] Operation of the electric motor of the submersible pump is carried out in the following manner. When current is applied to the winding 10 of the stator 2, interaction of the magnetic field of the rotor 5, created either by permanent magnets or by currents in the short-circuited winding of the rotor (depending on the type of electric motor), with the currents in the winding of the stator creates a working moment and drives the output shaft of the electric motor into rotation.

[0017] The proposed construction makes it possible to reduce the weight and dimensions, including the diameter, of electric motors of submersible pumps, which makes it possible to expand the field of their utilization by servicing small diameter wells, and also to enhance the productivity of submersible electric pumps in small diameter wells.

[0018] The electric motor of a submersible pump that is made in accordance with the present invention is designed preferably for use as a drive for submersible pump units used in oil wells.

Claims

1. An electric motor of a submersible pump, including a body (1) with a laminated core (2) of a stator (3) arranged therein, in slots (9) of a tooth zone (8) of which multiturn sections of a winding (10) are disposed with face parts (11), and a rotor (5) spaced from the stator (3) by a gap (4), characterized in that the winding is made two-layer, the core (2) of the stator (3) comprises two parts (6, 7), an inner part including the tooth zone (8) with slots (9) open to the side of the periphery of that part (6), and an outer part (7) encompassing the inner and being an annular yoke, each section of the stator (3) winding (10) has a substantially square cross section and is formed by turns (12) of wire of substantially rectangular cross section, the turns lying adjacent each other along their large surfaces, wherein a first and a second side of each section are positioned in different layers (13, 14) of the two-layer winding (10) so that in each slot (9) the large surfaces of the turns (12) in the first and second layers (13, 14) of the winding (10) are oriented mutually perpendicular, and the height of the face parts (11) does not exceed the height of the slot(9).

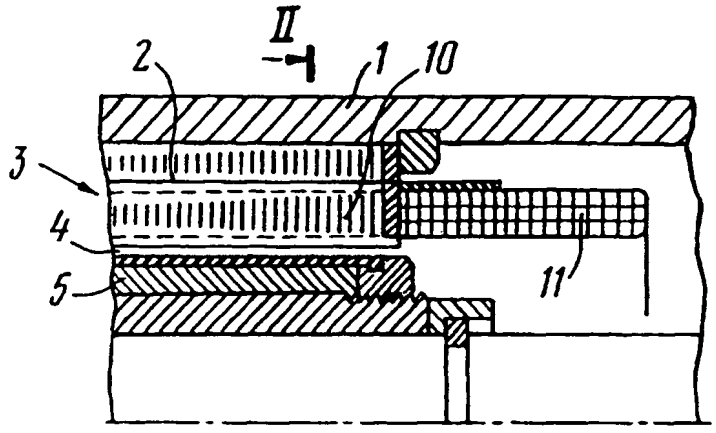

FIG.1

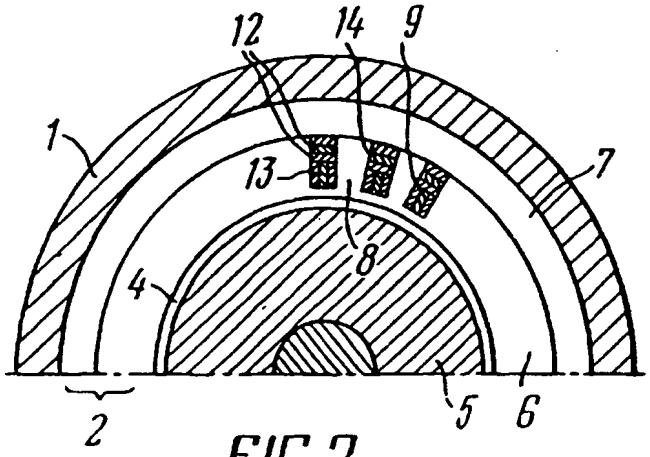

FIG.2

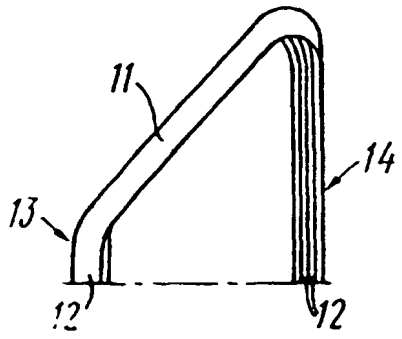

FIG.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ RU 99/ 00026

A. CLASSIFICATION OF SUBJECT MATTER [6]:
IPC6 H02K 3/12, F04D 13/08, F04B 47/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC6 H02K 3/00-3/12, 5/00, 5/12, 29/00, F04B 47/00, F04D 13/00, 13/08-13/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RU 2030058 C1 (MAXIMOV VITALY SERGEEVICH) 27 February 1995 (27.02.95)	1
A	RU 2083047 C1 (AKTSIONERNOE OBSCHESTVO OTKRYTOGO TIPA OSOBOE KONSTRUKTORSKOE BJURO BESSHTANGOVYKH NASOSOV - " OKB BN-KONNAS" 27 June 1997 (27.06.97)	1
A	GB 2140629 A (CATERPILLAR TRACTOR CO.) 28 November 1984 (28.11.84)	1
A	CH 679173 A5 (LU, FENGSHENG, XIAN) 31 December 1991 (31.12.91)	1
A	GB 1070344 A (MINISTERUL INDUSTRIEI PETROLULUI SI CHIMIE) 1 June 1967 (01.06.67)	1
A	DE 4234129 A1 (HILL, WOLFGANG) 5 May 1994 (05.05.94)	

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Date of the actual completion of the international search	Date of mailing of the international search report
18 March 1999 (18.03.99)	15 April 1999 (15.04.99)
Name and mailing address of the ISA/ RU	Authorized officer
Facsimile No.	Telephone No.

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